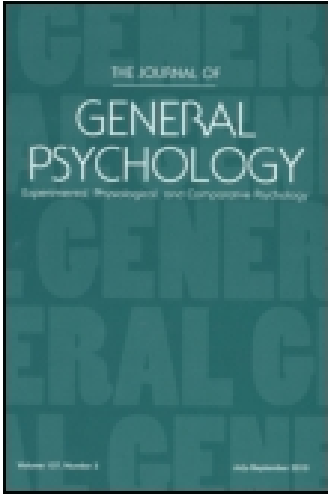


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CONDITIONING AND EXTINCTION AND THEIR RELATION TO DRIVE*

From the Biological Laboratories, Harvard University

B. F. SKINNER¹

It has been pointed out that in the description of behavior two activities may be distinguished: the demonstration of certain correlations between parts of behavior and parts of the stimulating environment (which may be called reflexes) and the discovery of the laws governing their states. The second activity is often necessary for the first, particularly with reflexes peculiar to the intact organism, the state of which depends upon such relatively unstable factors as the drive, the degree of conditioning, the state of various "emotions," and so on. The demonstration of a valid correlation between a stimulus and a response implies the availability of laws describing changes in the correlation due to such factors. For example, the behavior of a rat in seizing a bit of food can be held to be *lawful* only if it is possible to describe the conditions under which the stimulation supplied by the food will elicit the response or will not. In this case the strength of the reflex is a function of an inferred variable ("hunger"), which may be affected experimentally by feeding, fasting, certain drugs, pathological conditions, and so on. Similarly, if the reflex is a conditioned one, its strength will be a function of a variable having a similar status but in this case affected experimentally through reinforcement or lack of it.

Since it is possible to express the strength of a reflex at any given time as a function of a number of such variables, the description of behavior should be especially concerned with determining the minimal number to which appeal must be made and with their properties—how each varies with the experimental operations peculiar to it and defining it. This has already been done in a number of simple cases. Thus it has been shown how the strength of an (uncondi-

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tioned?) reflex associated with hunger varies with the ingestion of a standard food, where the strength of the reflex is indicated by its rate of elicitation under constant stimulation (3). A related conditioned reflex has been shown to vary in strength with ingestion in the same way (4). Similarly it has been shown how the strength of this conditioned reflex varies positively as the result of reinforcement (5) and negatively as the result of lack of reinforcement (6, 8). In these and other experiments incidental examples of what are presumably the result of changes in "emotion" have appeared (6-8), and in addition various spontaneous, but orderly, changes have indicated the existence of variables which have the same status but are for the moment beyond experimental control (7, 10).

These initial investigations have for obvious reasons been confined so far as possible to the study of one variable at a time. It is desirable, however, to proceed to the manipulation of two variables as soon as this can be done with reasonable rigor. At the present time it should be possible in the case of drive and conditioning and extinction, since the elementary properties of these variables are sufficiently well established. In the present paper three experiments are described which relate to the effect of different degrees of hunger upon the properties of conditioning and extinction, principally of the latter. The hunger is varied by equal steps, and the effect is observed upon typical kinds of conditioning and extinction curves.

II

A technical problem presents itself in the matter of obtaining different degrees of hunger. The use of different periods of fast is open to the objection that the organism (the white rat) does not eat continuously. If it were true that food is ingested at a stable (necessarily low) rate, it would be possible by cutting off the supply of food at different times before the experiment to obtain an array of degrees of hunger having some relation (not necessarily linear) to the lengths of fast. But, as is well known, the rat ordinarily confines its eating activity to a few periods during the day. The method is valid only where this irregularity does not matter, which means during fasts of the order of several days. Since these induce extreme degrees of hunger, which are complicated by other factors, the method is useless for our present purpose.

The following procedure has been found to set up equally spaced stable degrees of drive, at least according to the measure of drive used herein. The rats are placed on a schedule of daily feeding, according to which they are allowed to eat freely once a day for a definite length of time (say, one hour). After about a week of this procedure a high and essentially constant degree of hunger is reached each day just before the time of feeding. One proof of the constancy follows from the interpretation of the stable strength of a reflex obtaining during periodic reconditioning [compare Figure 3 in reference (7) in the light of the experiments described below]. Some advantages of the method have been pointed out by Bousfield and Elliott (2). With this stable and essentially maximal value of the drive as a base, it is possible to reduce the value by feeding definite amounts of food or feeding for definite lengths of time just before an experiment. The two methods come to the same thing, since with a constant initial degree of drive the amount eaten is a function of the time (1, 3). It is only necessary to decide upon the set of values that will produce the desired degrees of drive in each case. Practically, it is better to use amount rather than time, because of possible temporary variations in the rate.

In some of the following experiments the amount to be eaten was placed in the apparatus. When the experiment began, the rat first ate the food, then went on with the experiment. Since the apparatuses were used for successive groups of animals, this method consumed a great deal of extra time, especially when large amounts of food were eaten. An alternative method was therefore devised. At a length of time prior to the experiment determined by the amount to be eaten, the rat was placed in a separate cage with the food. By starting the members of a group at different times it was possible to have them finish their different rations at approximately the same time, when the experiment proper was begun. The second method avoids the disadvantage of the first that, if a part of the food is accidentally dropped and not soon recovered, the rat may start the experiment prematurely.

III

The other conditions of the experiments were identical with those previously reported in connection with each type of curve. For

a description of the apparatus the reader is referred to earlier papers (3, 5, 6, 7). It may be summarized briefly as follows: An experimental box is sound-proof and dark. At one end a small horizontal lever may be pressed downward by the rat, and at the will of the experimenter the movement of the lever may cause a magazine to discharge a pellet of food (weighing .05 gram) into a tray, where it is accessible to the rat. All responses to the lever are recorded automatically on number-vs.-time graphs.

A curve of *extinction* is obtained in this way: the response to the lever is conditioned by establishing the connection between the lever and the magazine and is reinforced as often as desired; at some later time, when the drive has been suitably adjusted, the connection is broken, and the extinction curve follows (6, 8). In the case of *periodic reconditioning* single responses to the lever are reinforced with pellets of food at given intervals of time (in these experiments every five minutes). The rat assumes a constant rate of responding, which is a function of the frequency of reinforcement (7) and of at least one condition of the reinforcement (10). *Extinction after periodic reconditioning* is obtained by discontinuing the periodic reinforcement (7).

IV

The first experiment, which serves incidentally as a check upon the control of the drive, concerns the constant state obtaining under periodic reinforcement.

Group A. Four rats, 105 days old at the beginning of the experiment, were tested at four drives resulting from the feeding of zero, two, four, and six grams. The food was placed in the apparatus and was eaten before responses to the lever were elicited. Thereafter responses were periodically reinforced for one hour. Each rat was tested several times at each drive in random order during the 16 days of the experimental period. Of the 64 records obtained, two were lost through technical faults in the procedure or apparatus. The remaining 62 were distributed as follows: 16 at zero grams, 15 at two grams, 15 at four grams, and 16 at six grams, each rat contributing three or four records to each group.

The average rates at the four drives expressed as responses per hour are given as open circles in Figure 1. The relation between the

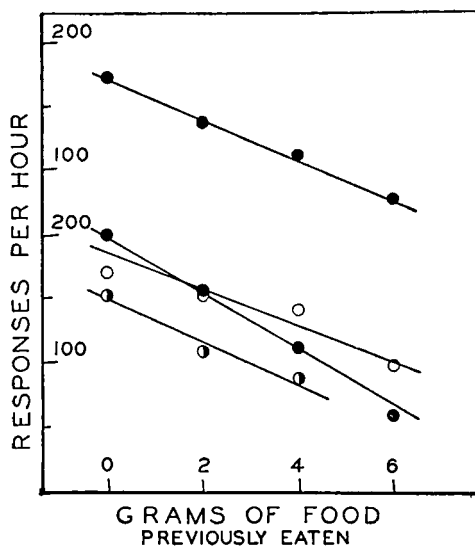


FIGURE 1

THE RATE OF RESPONDING UNDER PERIODIC RECONDITIONING (WHERE ONE RESPONSE IS REINFORCED EVERY FIVE MINUTES) INVERSELY VARIES WITH THE AMOUNT OF FOOD EATEN IMMEDIATELY BEFORE THE EXPERIMENT AFTER A FAST OF CONSTANT LENGTH

The lower curves are for groups of four rats each. The upper curve is the average for all three groups.

rate and the amount eaten is roughly linear. The best fit with a straight line extrapolates to an excessively high value for the amount of food necessary to bring the rate to zero. The line drawn through the points in the figure takes a more reasonable extrapolation into account.

Group B. Four rats (age not known but probably about five months) were tested at similar drives. The food was placed in the apparatus, and the rats ate it before responding to the lever. In this group each amount of food was fed to one rat on two successive days; but otherwise the amounts were shifted at random, each rat contributing a number of records at each drive. Forty records for periods of one hour each were obtained from the group. Four of these were lost through technical mistakes. The remaining 36 were distributed as follows: 10 at zero grams, 11 at two grams, 12 at four grams

and three at six grams. With these rats six grams of food reduced the rate to so low a value that considerable irregularity was encountered, and the experiment was therefore confined chiefly to the other values of the drive. The result for this degree should obviously not have full weight. The averages for all drives are given as the lower solid circles in Figure 1. It will be seen that the rate declines as a linear function of the amount fed, and in this case a better fit is obtained. Sample daily records for one rat at the four drives are given in Figure 2.

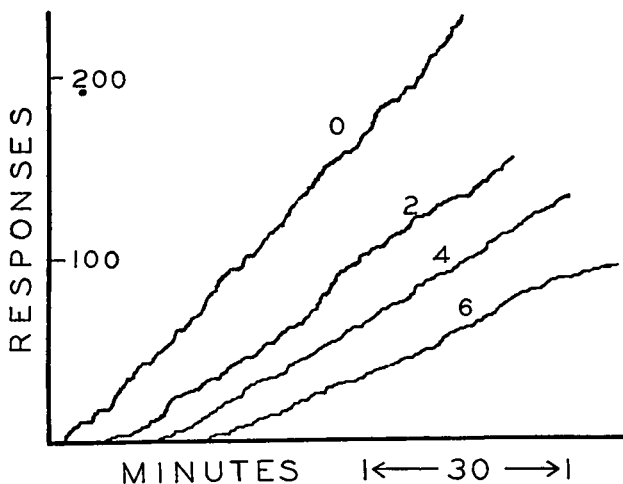


FIGURE 2

FOUR SAMPLE DAILY RECORDS MADE AUTOMATICALLY BY ONE OF THE RATS IN GROUP B (SOLID CIRCLES IN FIGURE 1)

The amount of food previously eaten in each case is indicated in grams at each record. The curve remains essentially a straight line in spite of its change in slope.

Group C. Three rats of the same age as in Group B were tested in the same way. Thirty records of one hour each were obtained from this group. None of these was lost for technical reasons, but three were at odd drives for the sake of exploration and are here omitted. The remaining 27 records were distributed as follows: nine at zero grams, eight at two grams, and ten at four grams. Two exploratory records at six grams (included above) showed that at

the resulting drive the rate was too low to yield a satisfactory result. The averages for all drives are given as shaded circles in Figure 1. The rates for this group are considerably below those of Groups *A* and *B* but show the same approximately linear relation to the amount previously eaten. Sample records for one rat at the three degrees of drive are given in Figure 3.

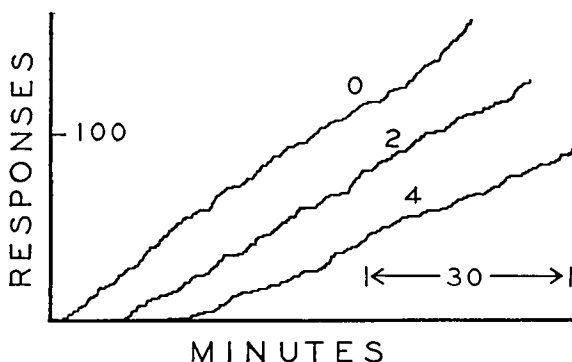


FIGURE 3

SAMPLE RECORDS FOR ONE OF THE RATS IN GROUP *C* (SHADED CIRCLES IN FIGURE 1)

The amount previously eaten is indicated in grams at each record.

The averages for the three groups are given in the upper curve in Figure 1. The point at six grams is not to be taken as of equal weight because of the absence of a value for Group *C*, which raises the average because the extrapolation for the group passes below the average for the other two. At the higher drives, however, an average serves to reduce the scatter resulting from the smallness of the samples and to reveal more clearly the linear relationship. In evaluating the graph it may be noted that it includes every record made during the experiment with the few exceptions already mentioned. There has been no selection of any other kind.

V

It has previously been shown that, where every response is followed by the ingestion of a standard pellet of food, the rate of responding varies with time according to the equation

$$N = Ktn$$

where n is of such a value ($= 2/3$ very nearly) that the rate of responding varies, not linearly, but approximately with the reciprocal of the square root of the amount ingested (3). This would conflict with the present result if the rates were of the same sort in the two cases. But where every response is followed by the ingestion of food, the entire chain of reflexes involved in ingestion is elicited. If at any point in the normal eating curve the chain is broken by disconnecting the magazine (as in extinction), a much higher rate of responding is immediately observed. The absolute value of the rate at any one drive therefore depends upon how much of the chain is elicited. Whether the rates for the whole chain and for the first member have a constant ratio has not been determined. Under periodic reconditioning we are observing neither one rate nor the other, but a stabilized intermediate rate, the significance of which will be shown in a moment by converting it to the extinction ratio. Its value need not be a linear function of the drive as determined from the normal eating curve. That it definitely is not follows from the present case if it be assumed that the rate of ingestion of the different amounts prior to the experiments followed the typical ingestion curve.²

VI

A change in the rate of responding under periodic reconditioning is necessarily a change in the extinction ratio, at least if the new rate is maintained at a stable value as in the present case (see below). But the ratio is a measure of the effect of the reinforcement and varies with the conditions under which reinforcement is made (7, 10). Hence we may express the first result of the present experiment as follows: the reinforcing effect of a pellet of food varies linearly with the amount of food already eaten.

The proof for this depends upon the stability of the rate at each drive, which can be determined either by measuring the slope on successive days at one drive or by measuring the curvature of the

²It will be understood that such an experiment could not be performed if the initial reflex in the act of ingestion resembled the response being tested for the extinction ratio, because the repeated reinforcement due to the ingestion would invalidate the ratio subsequently obtained—directly if the two reflexes were the same, through induction if they were merely similar.

daily records. In both cases evidence is obtained which indicates that a mere change in the value of the extinction ratio is not the only result of a change in drive. For it has been shown in experiments in which the ratio has been modified in other ways that the records obtained when changing from one condition to the other include an extinction curve when the change is downward and a reconditioning curve when the change is upward. This is a necessary characteristic, and if a change in the effect of the reinforcement is the *only* result of the change in drive, both the curvature of the records and the slopes on successive days should indicate the presence of extinction and reconditioning. This, however, is not observed.

If the height of a daily record is measured at the middle and the end of the hour, the former height should be one-half the latter if the curve is a straight line. Deviations from the expected middle value will be expressed as percentages. In the present case we want to know first whether there is any curvature as the result of passing from a higher to a lower drive. Measurements of all records at a drive lower than that of the preceding day were grouped together and the average curvatures were found to be of the following directions and magnitudes: Group *A*: +1.1 per cent; Group *B*: -3.2 per cent; Group *C*: -6.0 per cent. The average (algebraic sum/3) is -2.7 per cent. This is probably an insignificant value, and in any event it is in the wrong direction for indicating the presence of an extinction curve. In passing from a more effective reinforcement to a less effective the rate normally begins at the higher value and falls off to the lower. The curve is convex *upward* (10); but in the present case the slight curvature is in the opposite direction.

Similarly, there is no indication of the presence of reconditioning in the records at drives higher than that of the preceding day. When these are grouped together, the resulting curvatures are: Group *A*: +4.1 per cent; Group *B*: +0.6 per cent; Group *C*: +2.2 per cent. The average is +2.3 per cent. Normally, when the change concerns the effect of the reinforcement alone, the record for the day at a *stronger reinforcement begins at the lower rate previously obtaining* and adjusts during the hour to the new value. The result is that the curve is convex *downward*, but in the present case this condition is not fulfilled.

In agreement with the lack of significant relation between the

curvature and the value of the drive on the preceding day is the failure to find any consistent significant relation between the slopes of successive days. In the case of Groups *B* and *C* the days were paired in an attempt to disclose a correlation, which would be positive if there were any carry-over from one day to the next, negative if there were contrast. The averages for all pairs of days which follow a lower slope are 183 and 153 for the first and second days respectively, which show contrast. That is to say, the first day at the higher slope is especially high because it follows a lower slope. But the averages for all pairs following a higher slope are 107 and 102, which shows a trend in the same direction that cannot be a case of contrast. [Some drift in this direction is to be expected from the spontaneous decline of the extinction ratio (7)]. And a similar inconsistent result is obtained from Group *A* by averaging all values at any one drive in groups according to the preceding drive. Not all such groups are represented, as the random change in drive was not well distributed; but the following determinations (and no others) can be obtained from the data: (*a*) (showing contrast) the values for all records at zero grams following a day at six grams are 11 per cent higher than those at zero grams following a day at four grams; the values at four grams following a day at six grams are 11 per cent higher than those at four grams following a day at two grams; (*b*) (showing the opposite) the average value of all records at two grams following days at zero grams are 11 per cent *higher* than those following a day at four grams; and the values at six grams following zero grams are 12 per cent higher than those following four grams. These irregularities are probably due to sampling; and, for the present degree of approximation at least, it may be concluded that no carry-over or contrast effect is to be observed.

It is clear, therefore, that changing the drive does more than change the effect of the reinforcement. In addition to the change in ratio we are dealing with a true change in rate. This distinction may be amplified as follows. Suppose that a stable state under periodic reconditioning at full drive has been maintained for one or more days. If on the following day the reconditioning is omitted altogether, the rate does not drop to zero immediately but falls off along an extinction curve. Similarly if, instead of omitting the

reinforcement, a less effective reinforcement is substituted (say, less frequent or delayed), the rate does not drop immediately to the new lower value but approaches it *via* an extinction curve (10). The rate on the second day is partly due to the new reinforcement, but it is also partly due to a relatively large reserve established by the stronger reinforcement on preceding days. Our present result is that the change in drive affects not only the extinction ratio (that is, merely the effect of the reinforcement) but also the rate of responding as a function of the previously established higher state. We are thus led to inquire into the effect of the drive upon the pure extinction curve after periodic reconditioning, uncomplicated by periodic reinforcement at a lower value.

VII

First, however, it will be convenient to consider here another question concerning curvature which bears upon the method of obtaining different drives. The average curvatures for all records grouped together according to drives are given in Table 1. The

TABLE 1
CURVATURE AT DIFFERENT DRIVES (in percentage)

Grams fed	0	2	4	6	Average
Group <i>A</i>	0.0	+8.5	+7.7	0.0	+4.1
Group <i>B</i>	+2.2	-4.7	-8.6	—	-3.7
Group <i>C</i>	-0.5	+0.9	+4.5	—	+1.6
Average*	+0.6	+1.6	+1.2	0.0	+0.7†

*Signs taken into account.

†Calculated from the column, not the row, to avoid undue weight to the single value at 6 grams.

average values are either zero or slightly positive, and in no case can they be held to be significant. Even at the low rates obtaining under six grams, the records are straight lines. It is thus shown that if a rat is interrupted during the ingestion of a daily ration of food, the degree of hunger existing at that moment will persist without significant change for at least one hour. We are omitting the possible effect of 12 pellets of food administered periodically during the hour, having a total weight of a little over one-half gram. In one sense, of course, we are here lifting ourselves by our own bootstraps. We start out to discover whether the degree of

drive has any effect upon the periodic slope; we then use the periodic slope to show that the drive is constant during an hour. But the circularity is only apparent. We show that we are able to produce either a decrease in rate by permitting the ingestion of food, or, from one day to the next, an increase by withholding food. We then show that no change takes place during the hour similar to that which would be produced by further feeding or fasting. Some such change might have been expected, as the result either of the digestion of the food already eaten or of the newly begun fast.

VIII

The extinction curve that follows periodic reconditioning is rarely marked by the emotional disturbances that characterize original extinction. Except after very prolonged reconditioning the curve is relatively smooth and stable. Its behavior in relation to changes in drive has been investigated in the following way.

Fifteen rats were taken from other experiments which had involved periodic reconditioning for various lengths of time, as follows: four rats from an experiment on the effect of an interval of time before reinforcement (10), involving 23 days of periodic reconditioning; three from a similar experiment for 19 days (a fourth in this group had been accidentally killed); four from a similar experiment for 22 days; and four from an experiment on periodic reconditioning, where various numbers of successive responses were reinforced at each period, for ten days. The reconditioning interval was five minutes in each case.

Immediately before the experimental period in which extinction was observed the drives were varied by feeding zero, two, four, and six grams as above. One animal in each group was assigned to each drive (no case for six grams in the group of three). On the second and third days of extinction the drives were all maximal, no food being given prior to the experiment.

The resulting averages are plotted as the lower set of curves in Figure 4. On the first day of the graph the average rate under periodic reconditioning for two days prior to extinction is given, and on the second, the average slopes of the extinction curves at the different degrees of drive. Four measurements of the heights of the latter records were made in order to follow the change during the

hour. The third and fourth days of the graph show a continuation of the curves at maximal drive, only the end-points being measured. In their original form the data are difficult to interpret because the effect of the drive is to some extent obscured by the influence of the previous periodic slopes. These differed slightly, and, as has already been shown, the slope of the extinction curve is a function of the periodic slope (7). A rough correction is possible by multiplying the data for each group by a factor chosen to bring the periodic rate to some arbitrary value. In this case the value for the group at no grams was used, the necessary factors being 0.00, 1.32, 1.15, and 1.14 for the groups at zero, two, four, and six grams respectively. The resulting curves are given in the upper group in Figure 4, where the effect of the drive is clearly shown. (It may be noted that the factors chosen for this correction are based upon data available prior to the beginning of extinction.)

The curve at no grams in this figure is typical of the extinction curve previously reported (7). Its principal characteristic is that it begins at a rate considerably higher than that observed under the preceding periodic reconditioning. Most of the curvature of the first day is due to this initially higher rate, or to what has been spoken of as "overshooting" (7). The effect of the reduction in drive is apparently first of all to remove the overshooting and then to reduce the slope of the curve. It will be seen that the initial rate shows a consistent decline corresponding to increases in the amount of food previously eaten. The decrease is not, however, a linear function of the amount eaten but is most severe at the first step. Whether this can be attributed to the removal of overshooting as a separate effect cannot be established on the present evidence.

On the following day, at maximal drive, the curve at no grams declines as usual but the others show an increase in rate, not only above their previous values at the reduced drives, but also above the contemporary record for the group at no grams. Such an increase, which is the more pronounced the lower the drive, is to be expected from the following interpretation of the effect of drive upon the extinction curve.

It has already been pointed out that the extinction curve is the proper measure of the effect of conditioning (8). Conditioning may be described as the creation of a certain number of potential

responses which are later to be observed without further reinforcement. The number contributed to the total reserve by one reinforcement is the extinction ratio (7), which varies with the kind or condition of reinforcement (10, 11). According to this view the elicitation of a response without reinforcement simply subtracts one from the number in reserve, although it remains to be shown, of course, that the effect of a failure to reinforce is constant throughout the curve. One assumption that we can make about the rate of elicitation during extinction is that it is proportional to, or is some simple function of, the number of responses still to be elicited. Now, the effect of a change in drive may be to modify either the relation between the rate and the number of responses still to be elicited or the effect of the lack of reinforcement. The second of these possibilities is equivalent to saying that, if the rat is not very hungry, "failure to obtain food will matter less." If this second possibility may for the present be set aside, the assumption that the relation of the rate to the number of responses still to be elicited is modified by the change in drive is in good agreement with the present result. According to this view a certain number of responses, determined by the previous conditioning, is going to be observed in the extinction curve no matter what the drive. But at sub-maximal drives the average rate of responding is either proportionately reduced or restrained below a certain limit, and in either case the reduction of the number in reserve goes on more slowly. Consequently, the lower the drive, the lower the initial rate in extinction, but the slower the decline in rate.

In the experiments represented in Figure 4 the extinction curves were not continued at reduced drives long enough to test for the eventual appearance of a constant maximal number of responses in each case. But by returning to a full drive on the second day the same effect is shown in an accelerated form. According to the above interpretation, the effect of a change in drive upon the family of curves in Figure 4 is to postpone the appearance of some of the responses that would have been elicited on the first day of extinction and thus to shift the body of the curve to the right. A limiting case which illustrates this shift has been entered in the graph in broken lines. Here the drive on the first day of extinction is assumed to be so low that no responding occurs. Consequently no extinction

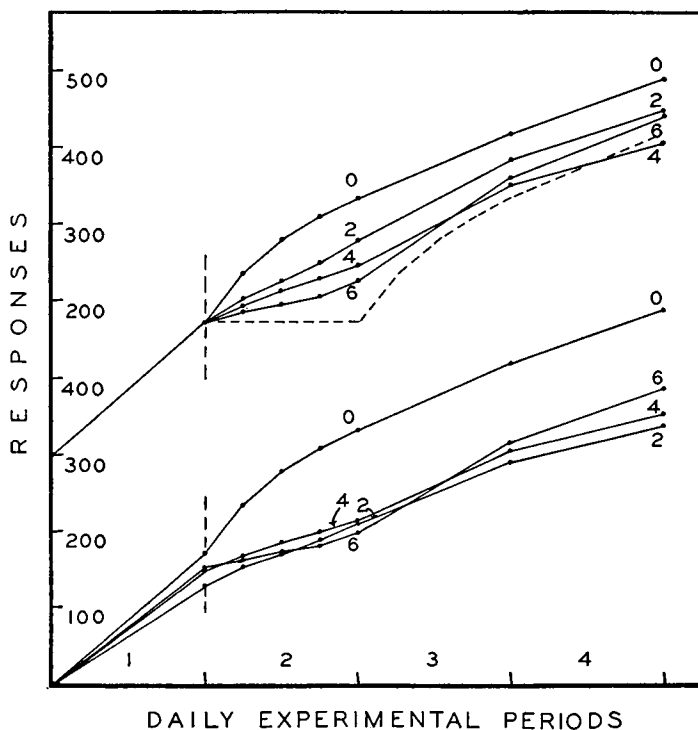


FIGURE 4

EFFECT OF LOWERED DRIVE UPON EXTINCTION AFTER PERIODIC RECONDITIONING

The lower curves give the original data, each curve representing the average for three rats.

The upper curves give the same data after being multiplied by factors chosen to superimpose the periodic slopes on the first day of the graph. On the second day the drives were reduced by feeding amounts of food indicated in grams at each record. The other days of the graph were at maximal drive. The broken line is the assumed case where no responding occurred on the second day.

occurs, and on the following day (the drive now maximal) the curve begins *ab initio* exactly as at zero grams on the first day. Here the whole curve has been moved one day to the right. In the case of six grams a similar effect is clearly shown. The low drive on the first day of extinction allows only a small number of responses to appear. The process of extinction is consequently not advanced very far, and

on the second day (at full drive) the rate is relatively high. A similar effect is detectable in the other two groups at reduced drive. The group at four grams, however, is obviously approaching a lower asymptote, which may mean that our correction is not wholly adequate or that there is a difference due to sampling.

IX

Since the rate under periodic reconditioning may likewise be assumed to be proportional to a number of responses still to be elicited (but a number which is kept constant through periodic replenishing), a similar change in the relation of the rate to the number will result in the lower constant rate that we observe. The final interpretation of the rate under periodic reconditioning is then as follows. During an experimental period at a lowered drive the rate is reduced in relation to the reserve as in pure extinction. Consequently not so much of the reserve is exhausted during the hour. If the input due to periodic reconditioning were normal, the reserve would gain; and on a subsequent day at full drive an increased rate would be observed. But the input is subnormal, because the effect of the periodic reinforcement is also reduced with the drive. To the degree of approximation represented by the present records the two effects act together in such a way as to balance each other at all times. The change in drive changes the behavior under periodic reconditioning without creating a debt or credit to be taken over on the following day at another drive. This is probably not a coincidence. In conditioning and extinction only one variable is involved, and it is as a whole that it is modified by the drive.

X

The effect of drive upon original extinction curves is more difficult to follow because of the relatively severe deviations that characterize them. Nevertheless some indication of the effect of hunger may be obtained; and it is in good accord with the interpretation advanced above. The experiments are as follows.

Twelve rats approximately 130 days old were conditioned in the usual way (see 5) and 20 responses reinforced. On each of two successive days 20 other responses were reinforced. After two days

on which the rats were fed in their cages at the experimental hour, extinction curves were obtained. Immediately before the experiment food was given to each rat in a separate cage as follows: to four rats no grams, to two rats two grams, to four rats four grams, and to two rats six grams. A representative record at each degree of hunger is given in Figure 5. The course of each curve is indicated

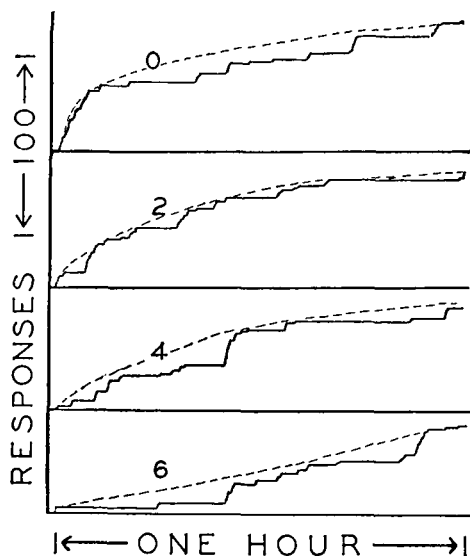


FIGURE 5

TYPICAL ORIGINAL EXTINCTION CURVES AT DRIVES RESULTING FROM THE FEEDING OF DIFFERENT AMOUNTS OF FOOD AS INDICATED IN GRAMS AT EACH RECORD

with a broken line, which is not offered as a theoretical curve as in a previous paper (6) but to show the character of the experimental curve more clearly.

The most important of the characteristics of original extinction which distinguish it from extinction after periodic reconditioning is its speed. Under the conditions of this experiment the greater part of the change in strength is normally completed by the end of one hour. Thus the curve at no grams in Figure 5 has closely approached a zero rate of responding by the end of the period. A second day

of extinction usually begins momentarily at a slightly higher rate (loss of extinction) but continues at a very low rate thereafter (6). In the present case, then, unless the postponement of responses by the reduction in drive is too great, we should be able to obtain in a complete form and within one hour a family of curves similar to that which in Figure 4 was interrupted by the return to maximal drive. With the exception of the curve at six grams, this is the case. To the degree of approximation remaining in spite of the irregularity it is apparent in Figure 5 that the animals reach a low rate of responding at the end of the hour. It is also apparent that this is accomplished in spite of a progressive reduction in the initial rate by the reduction in drive. The curves are thus in rough agreement with the assumption that the final height is not affected by the

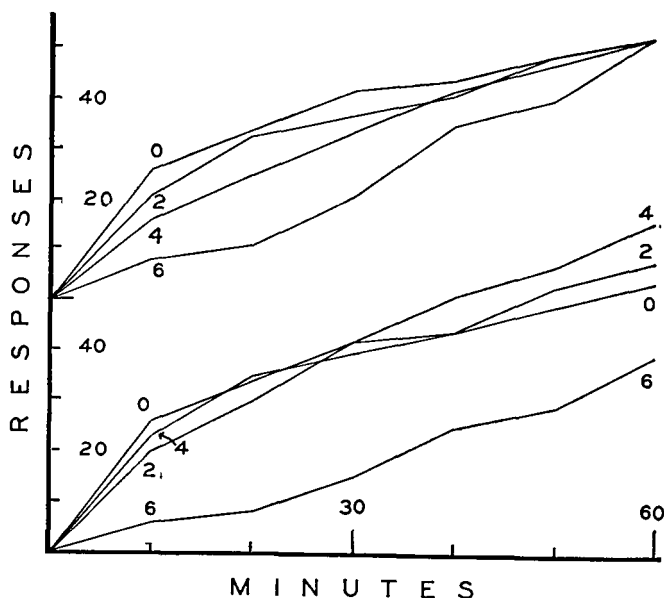


FIGURE 6

EXTINCTION CURVES OBTAINED BY AVERAGING INDIVIDUAL CURVES MEASURED AT SIX POINTS DURING THE HOUR

The amounts fed to reduce the drives are indicated at each record. The lower curves give the original data; the upper are the result of multiplying each curve by a factor chosen to superimpose the end-points. The numbers of cases represented by each curve are: at 0 grams 4, at 2 grams 2, at 4 grams 4, at 6 grams 2.

drive, and that the only effect is a modification of the relation between the rate of responding and the number of responses still to be elicited. In the case of six grams part of the curve has obviously been postponed too long to appear in the experimental period.

These comments hold as well for the averages for all records in the group, which are given in Figure 6. It should be noted that since the deviations in curves of this sort are all in one direction (i.e., below an envelope) an average will not correct for them. Indeed, it is doubtful whether an average is more useful than a single curve, except that it serves to express the result for the whole group. In the case of the raw data in Figure 6 (lower curves) the effect of the change in drive is again not very clearly shown because of the different slopes for the four groups. And unfortunately it is not possible to make a simple correction as in the case of extinction after periodic reconditioning, because we have no preceding data to work from. The number of responses to be elicited as the result of conditioning is not a simple function of the number of the preceding reinforcements when these occur grouped together. As has already been shown in periodic reconditioning, reinforcement of two responses every five minutes does not yield a rate twice that for the reinforcement of one response (7). Similarly, the number of responses in an original extinction curve bears no simple relation to the number of reinforcements that have preceded it, although the relation should be ascertainable. The present fact is that organisms differ rather widely in their extinction ratios and in the heights of original curves with comparable amounts of conditioning. It is therefore at present impossible to predict in advance what the height of an original extinction curve is going to be. If, however, we make the assumption that the same height is to be reached at the end of the hour (noting the improbability of the assumption in the case of six grams), we can multiply all values by factors chosen to bring the ends to some arbitrary point (say, the value for no grams). This has been done in the upper group of curves in Figure 6, where the required factors are 0.00, 0.93, 1.82, and 1.38. In this figure the characteristic effects of the change in drive that we have already noted in connection with the individual records may be observed.

SUMMARY

Three experiments bearing upon the relation of conditioning and extinction to the state of the drive upon which the conditioning is based are described. Equally spaced degrees of hunger are obtained by bringing a group of white rats to a daily maximal hunger and feeding different amounts of a standard food.

The constant strength of a conditioned reflex normally maintained under periodic reconditioning varies linearly with the amount of food previously eaten. Six grams of the food used reduced the strength nearly to half its original value. It follows from this relation and from the constancy of the strength at each drive that the effect of the reinforcement of a pellet of food varies linearly with the amount previously eaten. It also follows that the effect of the change in drive is to change the relation obtaining between the rate of responding and the number of responses still to be elicited.

Modification of the drive on the first day of extinction after periodic reconditioning causes a similar change in the rate of responding. The effect upon the curve is to reduce its initial rate, to retard its negative acceleration, and to leave the total number of responses composing it apparently unchanged. A similar effect is demonstrated in original extinction curves.

REFERENCES

1. BOUSFIELD, W. A. Certain quantitative aspects of the food-behavior of cats. *J. Gen. Psychol.*, 1933, 8, 446-454.
2. BOUSFIELD, W. A., & ELLIOTT, M. H. The effect of fasting on the eating-behavior of rats. *J. Genet. Psychol.*, 1934, 45, 227-237.
3. SKINNER, B. F. Drive and reflex strength: I. *J. Gen. Psychol.*, 1932, 6, 22-37.
4. ———. Drive and reflex strength: II. *J. Gen. Psychol.*, 1932, 6, 38-48.
5. ———. On the rate of formation of a conditioned reflex. *J. Gen. Psychol.*, 1932, 7, 274-286.
6. ———. On the rate of extinction of a conditioned reflex. *J. Gen. Psychol.*, 1933, 8, 114-129.
7. ———. The rate of establishment of a discrimination. *J. Gen. Psychol.*, 1933, 9, 302-350.
8. ———. "Resistance to extinction" in the process of conditioning. *J. Gen. Psychol.*, 1933, 9, 420-429.

9. ———. The extinction of chained reflexes. *J. Gen. Psychol.*, 1934, 20, 234-237.
10. ———. The effect upon the amount of conditioning of an interval of time before reinforcement. *J. Gen. Psychol.*, 1936, 14, 279-295.
11. ———. The reinforcing effect of a differentiating stimulus. *J. Gen. Psychol.*, 1936, 14, 264-278.

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LE CONDITIONNEMENT ET L'EXTINCTION ET LEUR RELATION AVEC L'ÉTAT DE L'IMPULSION

(Résumé)

On décrit trois expériences où il s'agit de la relation entre le conditionnement et l'extinction et l'état de l'impulsion sur laquelle se base le conditionnement. On obtient des degrés de faim également espacés en faisant avoir une faim quotidienne maximale à un groupe de rats blancs et en donnant à manger diverses quantités d'un aliment étalon.

La force constante d'un réflexe conditionnel maintenu normalement dans un nouveau conditionnement périodique varie linéairement avec la quantité de nourriture préalablement mangée. Six grammes de la nourriture employée ont réduit la force presque à la moitié de sa première valeur. Il suit de cette relation et de la constance de la force à chaque impulsion que l'effet du renforcement d'un morceau de nourriture varie linéairement avec la quantité préalablement mangée. Il suit aussi que l'effet du changement de l'impulsion est de changer la relation qui existe entre la vitesse des réponses et le nombre de réponse à faire naître après.

La modification de l'impulsion le premier jour de l'extinction après un nouveau conditionnement périodique cause un changement semblable de la vitesse des réponses. L'effet sur le courbe est de réduire sa vitesse initiale, de retarder son accélération négative, et de laisser le nombre total des réponses qui la composent non changé, paraît-il. Un pareil effet se montre dans les premières courbes d'extinction.

SKINNER

DAS BEDINGEN UND AUSSCHALTEN UND IHR VERHÄLTNIS ZU DEM STAND DES TRIEBES

(Referat)

Drei Experimente, die sich auf das Verhältnis des Bedingens und Ausschaltens zu dem Stand des Triebes beziehen, auf den das Bedingen gegründet ist, werden beschrieben. Gleich eingeteilte Grade des Hungers wurden durch das Bringen einer Gruppe weisser Ratten zu einem täglich Maximalhungers erreicht, worauf sie verschiedene Mengen von Futter erhielten.

Die konstante Stärke des bedingten Reflexes, die normal unter periodischer Wiederbedingung erhalten wird, variiert linear mit der Menge des vorher gefressenen Futters. Sechs gr. des Futters reduzierten die Stärke um

beinahe die Hälfte ihrer ursprünglichen Wertes. Es folgt aus diesem Verhältnis und aus der Konstanz der Stärke bei jedem Trieb, dass die Wirkung der Verstärkung eines Stückes Futter linear mit der Menge des vorher gefressenen Futters variiert. Es folgt auch daraus, dass die Wirkung der Veränderung in dem Trieb eine Veränderung des bestehenden Verhältnisses zwischen der Schnelligkeit des Reagierens und der Anzahl der Reaktionen verursacht, die noch hervorgebracht werden kann.

Die Modifizierung des Triebes an dem ersten Tage des Ausschaltens nach periodischem Wiederbedingen verursacht eine ähnliche Veränderung in der Schnelligkeit des Reagierens. Die Wirkung auf die Kurve ist die Reduzierung ihrer Anfangsschnelligkeit, die Hemmung ihrer negativen Beschleunigung, und das Stehenlassen der Gesamtanzahl der Reaktionen scheinbar unverändert. Eine ähnliche Wirkung wird in ursprünglichen Ausschaltungskurven nachgewiesen.

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